Comment on "Probing the Nuclear Liquid-Gas Phase Transition"

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In a recent paper Pochodzalla *et al.* [1] report a tantalizing dependence of nuclear temperature upon excitation energy. This dependence is characterized by an initial rise, followed by a wide plateau and a subsequent rise. The authors tentatively ascribe the initial rise to "ordinary" evaporation, the middle plateau to a liquid-vapor phase transition, and the final rise to a nearly ideal gas dependence for the overheated vapor.

The question arises whether the entire experimental curve can be interpreted in terms of equilibrium thermodynamics. If so, several problems arise. For instance, the claimed distinction between the initial rise (interpreted as the fusion-evaporation regime) and the plateau (hinted at as liquid-vapor phase transition) is not tenable, since evaporation is the liquid-vapor phase transition and no thermodynamic difference exists between evaporation and boiling.

Furthermore, the "caloric curve" requires for its interpretation an additional relationship between the variables T, P, and V. More to the point, the plateau is a very specific feature of the constant pressure condition rather than being a general indicator of a phase transition. For instance, a constant-volume liquid-vapor phase transition is not characterized by a plateau but by a monotonic rise in temperature. This can be easily proven by means of the Clapeyron equation, which gives dP/dT along the univariance line (liquid-vapor transition) together with the ideal-gas equation for the vapor [2].

As an example, Fig. 1 shows a standard temperature T vs entropy S diagram for water vapor. The region under the bell is the phase coexistence region. For the constant pressure curves ($\Delta S = \Delta H/T$), the initial rise along the "liquid" curve is associated with pure liquid, the plateau with the liquid-vapor phases, and the final rise with overheated vapor. The constant volume curves ($\Delta S = \Delta E/T$) cut across the coexistence region at an angle, without evidence for a plateau.

Thus one concludes that the alleged reminiscence of the observed "caloric curve" with "the paradigm of a phase transition" may be more pictorial than substantive, and that indicators other than the plateau may be needed to substantiate a possible transition from one to two phases. More specifically, *an additional relationship* between the three variables P, T, V (like P=const, or V=const, etc.) *is needed to interpret a T-E diagram unequivocally.*

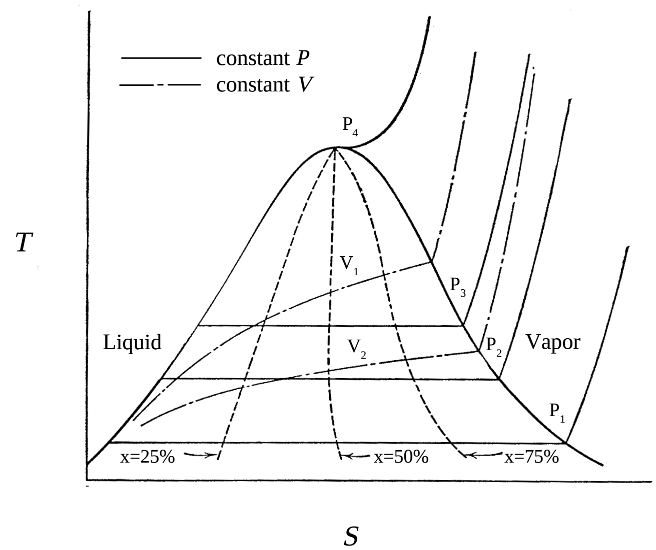

FIG. 1. Temperature-entropy diagram for steam. Curves are shown for constant pressure ($P_4 > P_3 > P_2 > P_1$), constant volume ($V_1 < V_2$) and constant percentage in the gas phase (dashed lines).

[1] J. Pochodzalla *et al.*, Phys. Rev. Lett. **75**, 1040 (1995).
[2] L.G. Moretto *et al.*, Phys. Rev. Lett. **76**, 2822 (1996).